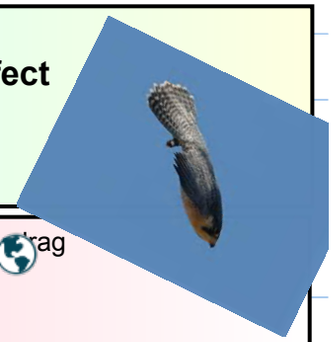
3.2.2 Motion with non-uniform acceleration

	Learning outcomes		Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:		
(a)	drag as the frictional force experienced by an object travelling through a fluid		
(b)	factors affecting drag for an object travelling through air		HSW6
(c)	motion of objects falling in a uniform gravitational field in the presence of drag		HSW9
(d)	**(i)**	terminal velocity	HSW1, 5
	(ii)	techniques and procedures used to determine terminal velocity in fluids.	**PAG1** e.g. ball-bearing in a viscous liquid or cones in air. HSW4 Investigating factors affecting terminal velocity.

(6) M - Define draw and state the factors that affect it.
(7) S - Describe the motion of an object falling in the presence of drag
(8) C - Understand techniques and procedures used to determine terminal velocity.

Lesson 3. Drag and terminal velocity

STARTER: Describe the drag force acting on this falcon. State factors affect it magnitude.



Extension: What is terminal velocity? How is it achieved?

Activity: Read 54: Add to your notes about drag. Key questions:
1. Meaning of a fluid?
2. Relationship between speed and drag? / graph to show this

The drag force can be calculated using the following equation:

$$F = \tfrac{1}{2} \rho C_d A v^2$$

F = drag force
ρ = density of air (or liquid)
C_d = drag coefficient
A = front cross-sectional area
v = velocity

(6) M - Define draw and state the factors that affect it.
(7) S - Describe the motion of an object falling in the presence of drag
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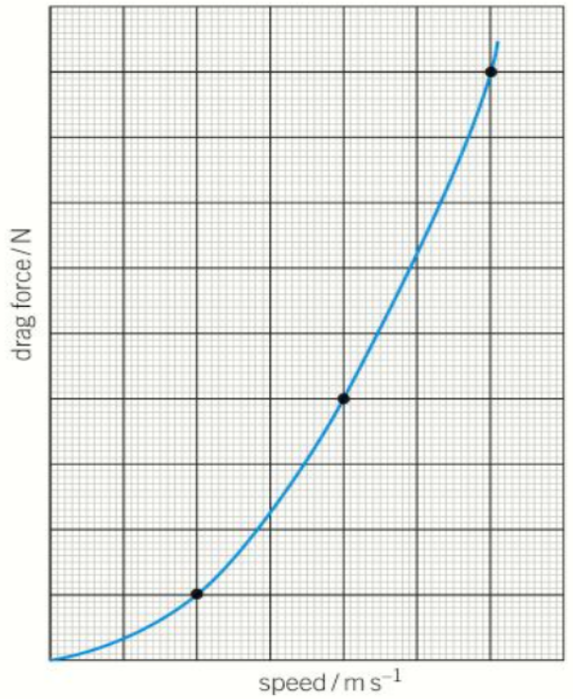
Lesson 3. Drag and terminal velocity

What is the relationship between speed and drag?

Show your answer mathematically



(6) M - Define draw and state the factors that affect it.
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g = 9.81

Activity: Explain / sequence why an object dropped from rest first accelerates then reaches terminal velocity (8)

falcon

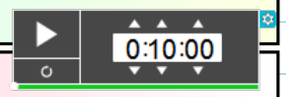
First accelerates because weight greater than drag (drag =0) **RF non-zero**	acceleration decreases because drag increase with speed. **RF decreases**	Speed increases until drag = weight **RF = 0**	Acceleration = 0 as **resultant force = zero.** Therefore constant speed (terminal velocity)

Ex: Explain the effect on the magnitude of the terminal velocity by increasing the mass of the falcon.

(6) M - Define draw and state the factors that affect it.
(7) S - Describe the motion of an object falling in the presence of drag
(8) C - Understand techniques and procedures used to determine terminal velocity.

ACTIVITY: Use the graph of the skydiver to complete the sheet to find: Velocity, acceleration, weight, drag and resultant force,

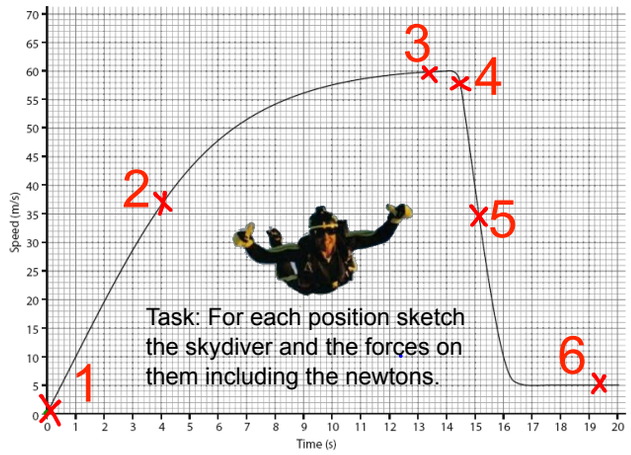
The skydiver weight is 60kg



Kilo 10^3
Mega 10^6
Giga 10^9

Hint: Find weight using W=mg

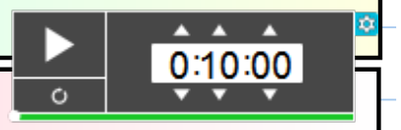
Compare qualitatively the **change in drag** from 2 to 3, to the **change in Speed** in the same period.



	Velocity (from graph)	**Diagram** (draw weight and drag forces including magnitudes)	**Resultant force**	**Acceleration.**
1. Start of jump (free-fall)				
2. accelerating				
3. Terminal Velocity				
4. Parachute starts to open				
5. deccelerating				
6. Terminal Velocity				

(6) M - Define draw and state the factors that affect it.
(7) S - Describe the motion of an object falling in the presence of drag
(8) C - Understand techniques and procedures used to determine terminal velocity.

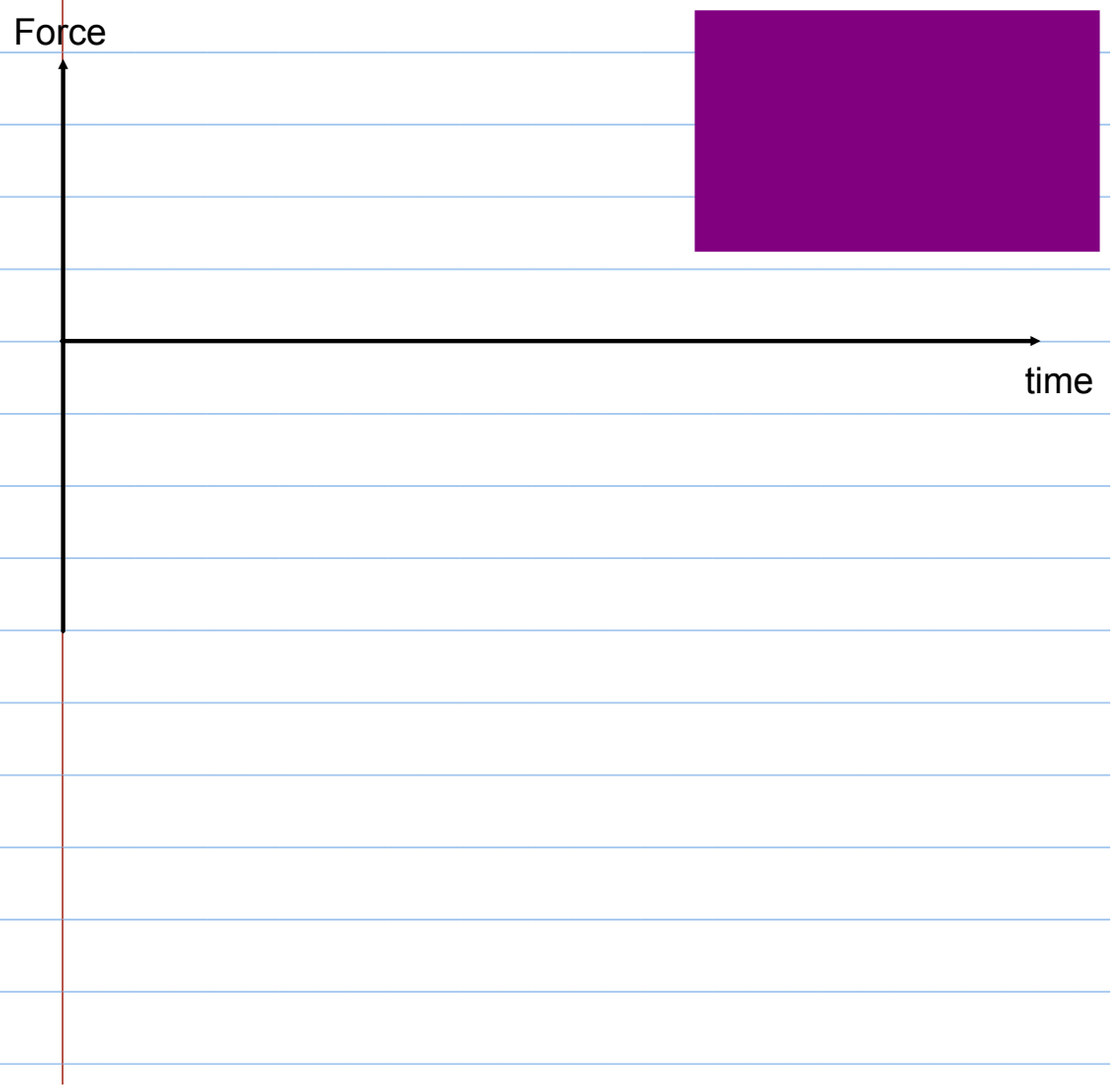
ACTIVITY: In pencil, sketch a graph of forces acting against time on the skydiver, for the whole 20 seconds
Consider: Weight, Drag and Resultant force



Kilo 10^3
Mega 10^6
Giga 10^9

Assume down is positive

Compare qualitatively the **change in drag** from 2 to 3, to the **change in Speed** in the same period.



(6) M - Define draw and state the factors that affect it.
(7) S - Describe the motion of an object falling in the presence of drag
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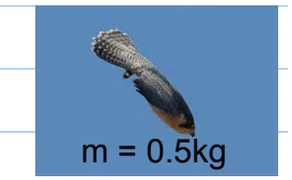
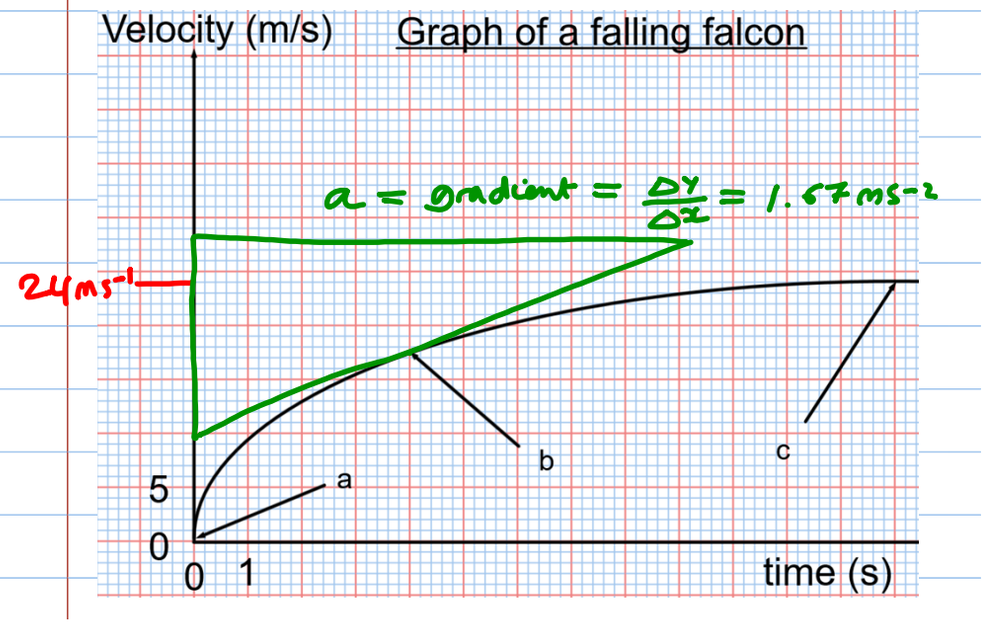
Lesson 3. Drag and terminal velocity

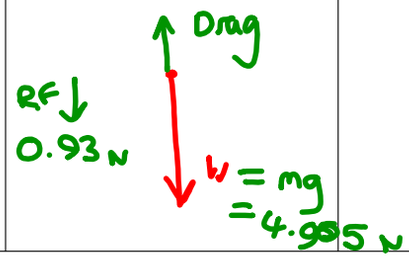
video

Activity: Complete the activity sheet of a falling falcon





Q2. Sketch a free body force diagram for the falcon in position a b and c.

a	b	c
		

Q3. Find the acceleration of the falcon at b.

1.67 ms-2

Q4. Calculate the drag force on the falcon at b. Add this drag value to your diagram.

(R.F) F = ma = 0.5 x 1.67 =